Time-dependence of bioenergy emission intensities and strategies to reduce pay-back times

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Outline

- Introduction
- Bioenergy examples
- Sensitivity
- Policy criteria & indicators
- Conclusions

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Introduction

1. Understand usefulness of emission intensities
   - Simple indicators for policy makers
   - Consumption-based accounting systems
2. Develop strategies to reduce the payback time
3. Understand the risks in estimating impacts of bioenergy systems
   - Will the “carbon-investment” bring “carbon dividends”?
4. Bioenergy type-profiles
   - Use versus decay
   - Use → regrowth
   - Growth → use
   - Annual crop (with iLUC)

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Use versus Decay
Forest residues

- Bioenergy System
  - Biorefinery producing bioethanol and phenols
  - Approx. 30% conversion efficiency
  - Supply chain emissions = 18 gCO2/MJ
- Reference System
  - Residues decay, average lifetime = 12.9 years
  - Gasoline, process emissions = 85 gCO2/MJ

From Cherubini et al – Task 38 Case Study
In press.
Use → Regrowth
Live biomass (trees) without risk

Bioenergy System
- Forest – 20 year rotation
- Biorefinery producing bioethanol and phenols
- Approx. 30% conversion efficiency
- Supply-chain emissions = 18 gCO2/MJ

Reference System
- Continued growth of forest
- Gasoline, process emissions = 85 gCO2/MJ

Use → Regrowth
Live biomass (trees) with risk

Bioenergy System
- Forest – 20 year rotation
- Biorefinery producing bioethanol and phenols
- Approx. 30% conversion efficiency
- Supply-chain emissions = 18 gCO2/MJ

Reference System
- Continued growth of forest
- 2% risk of loss to fire annually (assumed)
- Gasoline, process emissions = 85 gCO2/MJ
Growth \(\rightarrow\) Use

**New plantation**

- **Bioenergy System**
  - New plantation – 20 year rotation
  - Biorefinery producing bioethanol and phenols
  - Approx. 30% conversion efficiency
  - Supply-chain emissions = 18 gCO₂/MJ
- **Reference System**
  - Gasoline, process emissions = 85 gCO₂/MJ

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**Annual Crop**

**With landuse change**

- **Bioenergy System**
  - Sugar cane – based ethanol
  - Supply-chain emissions = 25 gCO₂/MJ
  - Direct land use change *fixed* so that payback time is 15 years
- **Reference System**
  - Gasoline, process emissions = 85 gCO₂/MJ
**Sensitivity Technology**

- **Bioenergy System**
  - Residues to wood chips to CHP
  - Approx. 27% conversion efficiency
  - Supply-chain emissions = 22 gCO2/MJ

- **Reference System**
  - Residues decay, average lifetime = 12.9 years
  - Coal burning CHP
  - Conversion efficiency 43.5%
  - Emissions = 248 gCO2/MJ

From GEMIS

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**Sensitivity Fossil energy replaced**

- **Bioenergy System**
  - Residues to wood chips to CHP
  - Approx. 27% conversion efficiency
  - Supply-chain emissions = 22 gCO2/MJ

- **Reference System**
  - Residues decay, average lifetime = 12.9 years
  - Natural gas CHP
  - Conversion efficiency 42.3%
  - Emissions = 173 gCO2/MJ

From GEMIS
Sensitivity Efficiency

- **Bioenergy System**
  - Residues to wood chips to CHP
  - Approx. 42% conversion efficiency
  - Supply-chain emissions = 22 gCO2/MJ

- **Reference System**
  - Residues decay, average lifetime = 12.9 years
  - Natural gas CHP
  - Conversion efficiency 42.3%
  - Emissions = 173 gCO2/MJ

From GEMIS

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### Policy Criteria & Indicators

- Current policy provides incentives for bioenergy systems that reach a specific emission intensity
- Emission intensities are time dependent
Policy Criteria & Indicators

- Policy should provide incentives for bioenergy that meets specific
  1. Conversion emission intensity
  2. Supply-chain emission intensity
  3. Payback time or recovery time
     \[ T_{\text{payback}} = f(I_B, I_S, I_F, T_{\text{return}}) \]
     - \( I_B \): Conversion emission intensity
     - \( I_S \): Supply-chain emission intensity
     - \( I_F \): Displaced fossil fuel intensity
     - \( T_{\text{return}} \): Recovery time (e.g. decay rate, rotation length)

Conclusions

- Emission intensities of bioenergy systems are time dependent
- Payback period can be minimised by using bioenergy
  - From purpose grown biomass (e.g. new short rotation forests)
  - To replace appropriate technology
  - To replace carbon intense fossil energy
  - With high efficiency
  - With quick recovery or natural return
- Policy criteria & indicators should consider
  - Conversion emission intensity
  - Supply-chain emission intensity
  - Payback time or rotation length / decay rate
- Risks will be different for different bioenergy type-profiles
Thank-you for your attention
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